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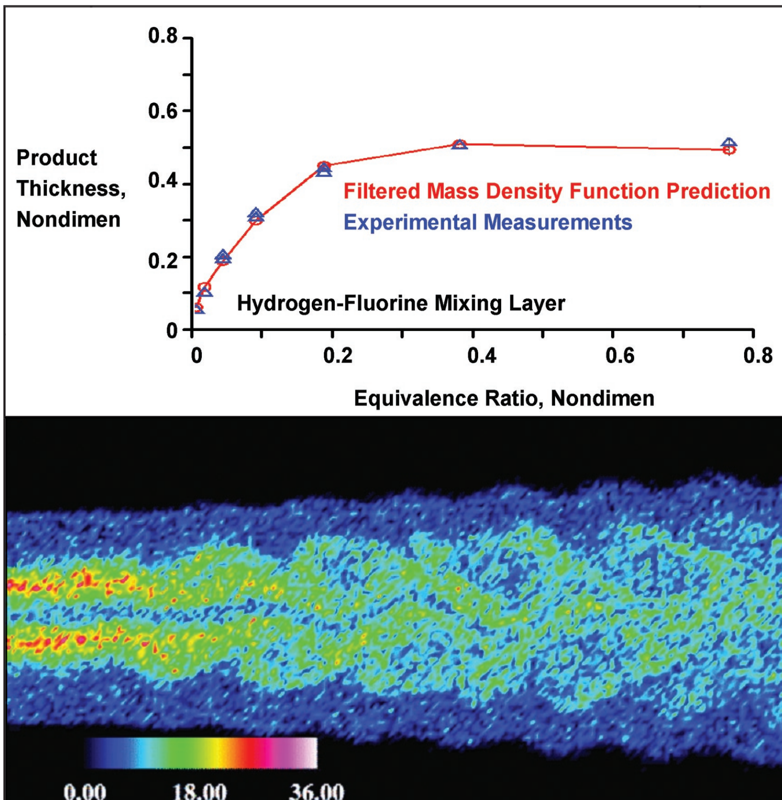
Science and Technology for Tomorrow's Air and Space Force

Success Story

LES USED TO DESIGN FUTURE AERO PROPULSION COMBUSTERS



Large Eddy Simulation (LES), developed by Air Force Office of Scientific Research (AFOSR)-sponsored research, represents the next generation of models that offers the promise of delivering quantitatively accurate assessments of combustor behavior in a computationally tractable manner. Using the LES approach, future propulsion systems will offer stable performance over a wide range of flight conditions, while meeting the stringent requirements for fuel economy and emissions for both military and civilian communities.

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Accomplishment

Dr. Sunil James of the Rolls-Royce Corporation in Indianapolis, Indiana, is currently testing and incorporating an LES-based combustor design modeling capability, he created. Many regard this as the next major step in computational tools for aero propulsion system design. Dr. James took fundamental aspects of an LES model for turbulent combustion, formulated by AFOSR-sponsored research of his former professor Dr. Peyman Givi at the State University of New York at Buffalo, to design combustors for future aircraft propulsion.

Background

In the past 20 years, engineers used computational modeling as an essential methodology for gas turbine combustor design, as well as for the design of combustors used in other chemical propulsion systems including ramjets, scramjets, and chemical rockets. Previous design approaches, based on trial-and-error testing, proved costly, time consuming, and incapable of achieving optimum performance.

Current computational modeling approaches use variations of the Reynolds-Averaged Navier Stokes (RANS) approach to predict temporally averaged parameters associated with combustor performance. RANS models are very useful for qualitative analysis of an engine's performance; however, they do not allow for a true quantitative predictive capability.

The combustion research community is actively pursuing LES models for turbulent combustion. LES solves the conservation equations for mass, momentum, energy, and chemical species at the largest physical scales of the combustor.

LES predicts the behavior of these parameters at the smaller scales of the flows below the resolution limits of the computational grid with approximate models—subgrid-scale (SGS) models. Dr. Givi contributed a unique approach for SGS through a statistical treatment of the mass-weighted, small-scale properties of combustion in a scalar-filtered mass density function. Dr. Givi demonstrated both the accuracy and computational efficiency of this approach by comparing his prediction with experimental measurements for a turbulent mixing layer.

The Rolls-Royce Corporation produced aero propulsion system designs used on several items in the Air Force's inventory. Among those are the AE 2100D3 turboprop used in the C130J transport, the AE3007H turbofan on the Global Hawk surveillance aircraft, and the F136 turbofan for use on the F-35 Joint Strike Fighter.

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Additional information

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